LOW-TEMPERATURE LUMINESCENT SPECTROSCOPY AND CHARGE TRANSFER PROCESSES IN NANOMETER DIELECTRIC FILMS OF HAFNIUM-ZIRCONIUM-OXYGEN

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Using the methods of low-temperature luminescent spectroscopy, charge transfer processes in nanometer dielectric films of solid solutions of hafnium-zirconium-oxygen were explored.

Nanometer films of $Hf_xZr_{1-x}O_2$ solid solutions on a silicon substrate with a high permittivity (high-k dielectrics) are explored. The $Hf_xZr_{1-x}O_2$ permitivity is greater than that of silicon oxide, which makes it possible to reduce the size of the RAM cell. These films have a ferroelectric effect, the ability to maintain a given polarization without an external field. Their use as a gate dielectric will increase the electric field strength in the conductive channel, which will improve the performance of MOSFET and flash memory. The results of initial studies show the real possibilities of creating new technologies in the area of controlled formation of nanostructures with desired properties [1]. Understanding the mechanisms of transport of charges, determining the parameters of their capture centers will create a physical basis for monitoring and controlling the parameters of elements based on high-k dielectrics.

The spectra of stationary cathodoluminescence (CL), their temperature dependence in the temperature range of 9-300 K, the decay kinetics of pulsed CL are explored, and a comparison with photoluminescent (PL) studies is made. The films were synthesized and certified at the Rzhanov Institute of Semiconductor Physics of SB RAS [1]. To research CL, a home-built electron gun with an energy range of 0.4-1.0 keV was developed and manufactured. The energy range was chosen from the conditions of complete energy absorption of exciting electrons in the volume of nm-films. A special power supply unit was manufactured. The electron beam (size of spot is 1.5 mm^2 at sample) was brought into a vacuum cryostat ($P=10^{-6}$ mbar). A closed cycle cryogenic station was used. Figure 1 shows the CL spectrum and, for comparison, the PL spectra upon differ exciting photons.

Both spectra exhibit the emission bans in regions of 250-320 and 350-500 nm. According to Ref. [2] the wide long-wavelength emission band is caused by anion vacancies in different charge conditions. The shot wavelength emission band corresponds to the emission of self-trapped excitons [3]. CL spectra show that electron beam excites a defect-related luminescence more intensively. The energy of electron beam has a stronger effect on the CL intensity than the beam current. This fact indicates a higher concentration of emission centers (anion vacancies) in the film volume.

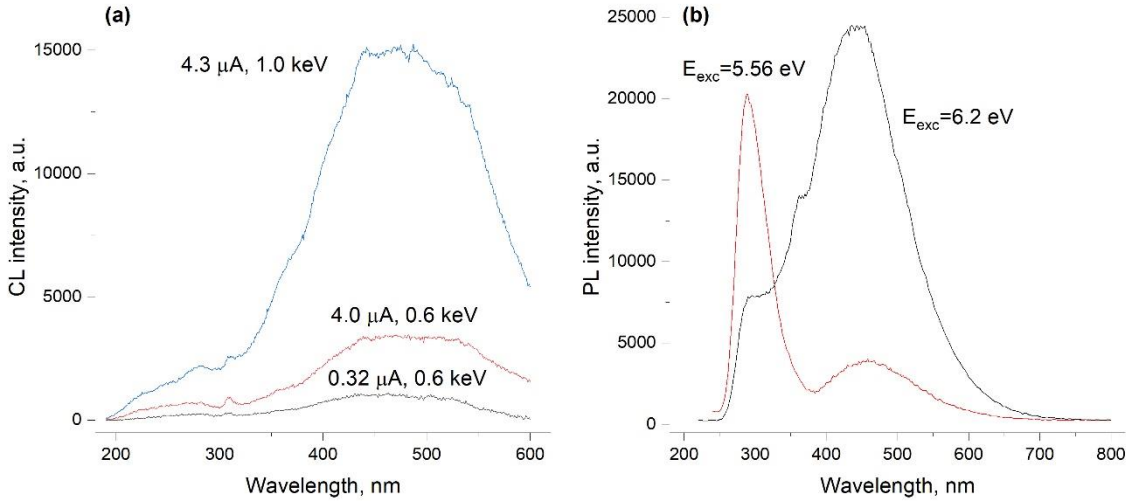

Figure 1. $Hf_{0.5}Zr_{0.5}O_2$ film, d=19.5 nm: (a) – CL spectrum at T= 9 K; (b) – PL spectra, T = 7 K, the energies of the exciting photons are shown

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